PJKK
RAIL MEASUREMENT SUMMARY
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Prepared by:

CHARLES M. SALTER ASSOCIATES, INC.
Peter K. Holst, P.E.
peter.holst@cmsalter.com
130 Sutter Street, Suite 500
San Francisco, CA 94104

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SECTION 1: INTRODUCTION

During the design phase of the PJKK Courthouse, noise from the proposed Honolulu High-Capacity Transit was analyzed using exterior noise intrusion criteria provided by the GSA P100 document. The analysis was based on the estimated train noise level generated by the Federal Transit Administration (FTA) and used by Parsons Brinckerhoff in the development of an Environmental Impact Statement (EIS).

Sound data was produced by the FTA model and used in the EIS. These estimated noise levels are based on a new track system. At the GSA request, we measured the noise generated by actively running light rail trains for comparison to the model. This report summarizes these measurements, compares the results to the FTA model, and provides recommendations based on interior noise calculations.

SECTION 2: EXECUTIVE SUMMARY

We measured three rail lines identified by Parsons Brinckerhoff as approximate equivalents to the proposed Honolulu High-Capacity Rail. According to Lawrence Spurgeon, a Supervising Environmental Engineer with Parsons Brinckerhoff, the Vancouver SkyTrain, which began operation in 2009, is the most similar to the proposed Honolulu rail system. Also similar are the Santa Clara Valley VTA and the Seattle Sound Transit.

Our measurements indicate that Vancouver SkyTrain noise levels are lower than the FTA model, Seattle Sound Transit noise levels are higher than the FTA model, and the Santa Clara Valley VTA noise levels are significantly higher than the FTA model.

Using the Vancouver SkyTrain noise levels, the proposed Honolulu rail system would be quieter than the PJKK criteria of 45 dBA established by the GSA P100 document, and would be approximately equal to the background noise generated by the HVAC system.

The Santa Clara Valley VTA rail has been in operation since 2001, and track wear has likely contributed to the increased noise levels. A six-foot tall parapet barrier along the rail line adjacent to the PJKK project can be expected to reduce these noise levels.

With possible mitigation, such as increasing the parapet barrier height and/or incorporating friction modifiers to reduce wheel squeal, we estimate the rail noise from all three similar systems could meet the 45 dBA criteria.

SECTION 3: FTA MODEL BACKGROUND

The FTA model used by Parsons Brinckerhoff for the Honolulu High-Capacity Transit rail study estimates a reference SEL[1] of 82 dBA at a distance of 50 feet. The single-event noise level (L_{max}[2]) is predicted to be 80 dBA at a distance of 50 feet.

The final EIS for the Honolulu rail line includes the use of wheel skirts. The FTA handbook predicts 2 dBA of noise reduction using wheel skirts. Only the Sound Transit system in Seattle included wheel skirts.

The nearest stop to the PJKK project is the Civic Center stop, approximately 1,000 feet east of PJKK along Halekauwila Street. The rail line is straight as it passes PJKK, with no turns within 2,000 feet in either direction.

SECTION 4: MEASUREMENT SUMMARY

Lawrence Spurgeon, a Supervising Environmental Engineer with Parsons Brinckerhoff, indicated that the Canada Line of the Vancouver SkyTrain, is the most similar to the proposed Honolulu rail system. Also similar are the Santa Clara Valley VTA and the Southcenter Boulevard section of the Seattle Sound Transit. Each measurement location is described in this section, with a brief description of the measurements. For more technical information, including sound data for each measured train passby, please refer to Appendix A. For photographs of each measurement location, refer to Appendix B.

SkyTrain Vancouver, Canada Line

On 27 August 2010, we visited two sites along the elevated track of the Skytrain Canada Line in Vancouver. We measured a typical L_{max} of **78 dBA** at a distance of 50 feet. These tracks began operation in 2009 and were predicted by Parsons Brinckerhoff to be the most similar to the proposed Honolulu rail.

The Vancouver track has a small (two to three feet tall) parapet barrier at the rail; however our elevated microphone placement was above the top of the parapet and eliminated the shielding provided by the barrier for the purpose of comparison to the FTA model.

The first location was along No 3 Road between Capstan Road and Cambie Road, approximately 1,250 feet north of Aberdeen Station Northbound. We measured three southbound and four northbound passbys at elevations of five and 35 feet above grade, and at set-backs of 50 and

[1] Sound Exposure Level (SEL) – A descriptor for the A-weighted noise exposure or dose of a transient event. The SEL can be thought to compress the sound energy of a single noise event into an equivalent sound level occurring in a one-second time interval.

[2] L_{max} – The maximum A-weighted sound level measured during a period of time.

75 feet from the near rail. For our measurements of passbys along the near track, we measured an average L_{max} of 78 dBA at a distance of 50 feet.

The second location was along an overpass above Cambie Street just south of Kent Avenue NW, approximately 1,700 feet south of Marine Drive Station Southbound. We measured six southbound trains and five northbound trains on an elevated walkway at set-backs of 50 and 75 feet from the near rail. The train tracks were approximately 15 feet above the walkway platform, and we measured at heights of five feet and 25 feet, relative to the walkway platform. For our measurements of passbys along the near track, we measured an average L_{max} of 74 dBA at a distance of 50 feet. The lower noise levels for the track at this platform location are likely a result of lower train speeds due to a sloped track.

Santa Clara Valley Transportation Authority (VTA) Light Rail

On 11 August 2010, we visited Milpitas to measure the noise from the elevated rail along Great Mall Parkway between McCandles Drive and Montague Expressway, approximately 1,500 feet northwest of Montague Station. We measured a typical L_{max} of **94 dBA** at a distance of 50 feet. This track began operation in 2001.

This section of the VTA rail has no wheel skirts or parapet barrier and is along a straight track. We measured five southbound trains and three northbound trains at elevations of five, 12, and 35 feet above grade, at set-backs of eight, 60, and 160 feet from the near rail. These noise levels are significantly higher than the FTA model predictions. The noise levels for this track are significantly higher than the other locations at the mid to high frequencies (centered around 1,250 Hz), which is heard as a squeal noise. Because this track has been in operation for nearly 10 years, we expect that the increased high-frequency noise levels are due to wear along the tracks and could be reduced by regular maintenance.

Sound Transit Link Light Rail, Central Link

On 25 August 2010, we visited two sites along the elevated Central Link track of the Sound Transit rail in Seattle. This track began operation in 2009 and has incorporated wheel skirts to reduce noise. The first measurement location included sites with and without shielding from a three foot tall parapet barrier. Without the shielding from the barrier, and with the 2 dB attenuation provided by wheel skirts subtracted, the train generates a typical L_{max} of **87 dBA** at a distance of 50 feet. The parapet barrier provided approximately 12 dBA of noise reduction, for a microphone equal in height to the top of the barrier. This matches the expected result from a calculation model.

The first location was along 52nd Avenue South, between Southcenter Boulevard and South 151st Street, north of the Tukwila International Boulevard Station. At our measurement location 800 feet from a low radius turn, with the train operating at a slightly reduced speed, we measured a typical L_{max} of 83 dBA.

In the area shielded by the three-foot tall barrier, we measured a typical L_{max} of 71 dBA at a distance of 50 feet. At this section of track, we measured a total of eight southbound trains and six northbound trains, at elevations of five, 12, and 35 feet above grade, all at a set-back of 50 feet from the near rail.

The second location was near the intersection of Macadam Road South and South 128th Street, along a straight section of track with no station nearby. We measured two southbound trains and one northbound train at elevations of 5 feet and 35 feet, at a set-back of 50 feet from the near rail. We measured an L_{max} of 85 dBA for passbys along the near rail.

Measurement Result Summary Table

Table 1 summarizes the results of our measurements at each site. Although the Seattle Sound Transit track has wheel skirts and a short parapet barrier, the data is based on calculations with these items eliminated so that each system could be compared equally.

Table 1: Measured noise level and sound-reducing feature descriptions

Measurement Location	L_{max} at 50 feet	Year Began Operation	Wheel Skirts?	Friction Modifiers?	Parapet Barrier?
Vancouver SkyTrain	**78**	2009	No	Unknown	No
Santa Clara Valley VTA	**94**	2001	No	No	No
Seattle Sound Transit	**87**	2009	No	Yes	No

SECTION 5: PJKK INTERIOR NOISE LEVELS AND RECOMMENDATIONS

Based on the project design, the spaces with the most exposure to the elevated rail are the 4th floor Judge's Chambers at the building corners with approximately fifty-percent glazing area. Using the FTA source noise level of L_{max} 80 dBA and the proposed laminated insulated glazing assembly, we had calculated that a train passby would have a maximum noise level of 42 dBA in these chambers.

Using our measurement data from the three locations described, and the third-octave band insertion loss data for the glazing assembly to be used, we calculated the estimated noise levels in the 4th floor corner chambers. Our calculations include the proposed three-foot parapet barrier and the use of wheel skirts. Table 2 provides the calculated interior noise level based on each location's measured data.

Table 2: Calculated interior noise level based on measured data at three sites, with three-foot parapet barrier and wheel skirts included in each calculation

Measurement Location	Calculated Interior L_{max} (dBA)
Vancouver SkyTrain	40
Santa Clara Valley VTA	**51**
Seattle Sound Transit	43

The interior noise level of 40 dBA calculated for the Vancouver SkyTrain, which is considered the most similar to the proposed Honolulu rail system, meets the project criteria of 45 dBA based on the GSA P100 document.[3]

For the VTA train, the calculated interior noise level of 51 dBA is higher than the criteria. A five dB difference would be considered an easily noticeable difference. Providing a six-foot barrier along the track where adjacent to the PJKK project would reduce the noise level, as compared to a three-foot barrier.

With regards to length of the parapet barrier, the Federal Building would need to be reviewed if any rooms along the Halekauwila Street facade are acoustically sensitive. The barrier would need to be long enough so that noise around the barrier edges does not exceed the noise calculated over the top. Our calculation model indicates that with a six-foot tall wall using non-absorptive materials, the barrier would need to extend approximately 175 feet beyond the northeast and southeast corners of the building.

To maintain an integrated design, the other design aspects for the barrier, including the view corridors along Mililani Street and Punchbowl Street, would need to be coordinated, affecting the types of materials used. For example, a sound-absorbing and sound-reducing material for the barrier would be more effective than a transparent non-absorptive sound-reducing barrier (i.e., glass). The height and length would need to be adjusted based on the materials ultimately selected. The calculation results that follow are based on the assumption that the barrier would only be on one side of the track.

With a six-foot tall non-absorptive barrier included in the elevated rail design, we calculate that the VTA train would be 47 dBA, the Sound Transit would be 38 dBA, and the SkyTrain would be 36 dBA at the 4th floor corner chambers.

The high-frequency "squeal" noise that we attributed to track wear for the VTA trains, could be reduced by using lubrication or friction modifiers[4]. With these features incorporated, we would expect the high-frequency noise levels to be reduced so that the overall noise level is reduced by at least 2 dBA, and the 45 dBA criteria is achieved.

Increasing the height of the barrier to eight from six feet would provide approximately 2 dB of attenuation. Increasing the height of the barrier to eight feet from six feet and providing a sound-absorbing barrier would provide approximately 4 dB of attenuation. Increasing the height of the barrier to ten feet from six feet would provide approximately 3 dB of attenuation.

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[3] The GSA P100 provides a goal for single-event noise levels to be no more than 5 dBA above the HVAC ambient, for which the design criterion is 40 to 45 dBA. The existing measured ambient in the 4th floor chamber office is approximately 40 to 45 dBA.

[4] Lubricators and friction modifiers have been installed in Seattle, based on an acoustical peer review of the Sound Transit system prepared by The Greenbusch Group, Inc. dated 14 July 2010.

It is important to note that our analysis is based on a straight "tangent" rail track with no cross-over tracks (i.e., "frogs"). The FTA model predicts that cross-over tracks increase single-event noise levels by 10 dB. At a section of the Vancouver SkyTrain track with and without crossings, we measured a noticeable increase of 4 to 6 dBA at the cross-over tracks.

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10-11-1 PJKK Rail Measurements 10-0318

A P P E N D I X A

Data Summary

Location #1: SkyTrain Vancouver, Canada Line

Measurements conducted 27 August 2010, using Larson Davis 824 and 831 meters with calibrated microphones.

Passby #	Train	Time	Location	Lmax (slow)
No 3 Road between Capstan Road and Cambie Road				
1	2-car northbound	12:10:59	35' above grade, 50' E of near rail	78
		12:11:00	5' above grade, 50' E of near rail	78
2	2-car northbound	12:18:27	35' above grade, 50' E of near rail	77
		12:18:29	5' above grade, 50' E of near rail	77
3	2-car northbound	12:26:27	5' above grade, 50' E of near rail	77
		12:26:29	5' above grade, 75' E of near rail	76
4	2-car northbound	12:33:30	5' above grade, 50' E of near rail	79
		12:33:33	5' above grade, 75' E of near rail	76
5	2-car southbound	12:07:34	35' above grade, 50' E of near rail	76
		12:07:29	5' above grade, 50' E of near rail	75
6	2-car southbound	12:15:03	35' above grade, 50' E of near rail	75
		12:14:59	5' above grade, 50' E of near rail	72
7	2-car southbound	12:30:09	5' above grade, 50' E of near rail	76
Cambie Street just south of Kent Avenue NW				
1	2-car southbound	13:45:18	25' above platform, 25' W of near rail	77
		13:45:16	5' above platform, 25' W of near rail	75
2	2-car southbound	13:49:04	25' above platform, 25' W of near rail	77
		13:49:04	5' above platform, 25' W of near rail	75
3	2-car southbound	13:52:49	25' above platform, 25' W of near rail	77
		13:52:49	5' above platform, 25' W of near rail	75
4	2-car southbound	14:07:49	25' above platform, 50' W of near rail	73
		14:07:50	5' above platform, 50' W of near rail	74
		14:07:53	5' above platform, 25' W of near rail	74
5	2-car southbound	14:11:34	25' above platform, 50' W of near rail	74
		14:11:34	5' above platform, 50' W of near rail	75
		14:11:38	5' above platform, 25' W of near rail	75
6	2-car southbound	14:15:18	25' above platform, 50' W of near rail	74
		14:15:20	5' above platform, 50' W of near rail	75
		14:15:23	5' above platform, 25' W of near rail	75
7	2-car northbound	13:48:01	25' above platform, 25' W of near rail	78
		13:47:59	5' above platform, 25' W of near rail	68
8	2-car northbound	13:51:42	25' above platform, 25' W of near rail	78
		13:51:40	5' above platform, 25' W of near rail	68

Passby #	Train	Time	Location	L_{max} (slow)
9	2-car northbound	14:06:37	25' above platform, 50' W of near rail	72
		14:06:39	5' above platform, 50' W of near rail	68
		14:06:43	5' above platform, 25' W of near rail	68
10	2-car northbound	14:10:30	25' above platform, 50' W of near rail	72
		14:10:29	5' above platform, 50' W of near rail	66
		14:10:32	5' above platform, 25' W of near rail	66
11	2-car northbound	14:14:11	25' above platform, 50' W of near rail	72

Third-octave band data for a typical train passby at 50 feet (L_{max} of 78 dBA).

Frequency (Hz):	**50**	**63**	**80**	**100**	**125**	**160**	**200**	**250**	**315**	**400**	
L_{max} dB:	72.0	70.0	69.2	65.2	67.3	65.9	66.4	66.8	65.2	67.3	
Frequency (Hz):	**500**	**630**	**800**	**1000**	**1250**	**1600**	**2000**	**2500**	**3150**	**4000**	**5000**
L_{max} dB:	66.2	68.9	72.7	68.4	68.4	66.5	62.8	61.9	58.4	55.8	52.9

Location #2: Santa Clara County VTA Light Rail

Measurements conducted 11 August 2010, using Larson Davis 824 and 831 meters with calibrated microphones.

Passby #	Train	Time	Location	L_{max} (slow)
Great Mall Parkway between McCandles Drive and Montague Expressway				
1	2-car Southbound	13:05:39	35' above grade, 60' SW of near rail	87
		13:05:37	12' above grade, 60' SW of near rail	86
		13:05:40	5' above grade, 60' SW of near rail	85
		13:05:35	12' above grade, 60' SW of near rail	85
2	4-car Southbound	13:21:30	35' above grade, 60' SW of near rail	93
		13:21:28	12' above grade, 60' SW of near rail	87
		13:21:34	5' above grade, 60' SW of near rail	90
		13:21:33	12' above grade, 60' SW of near rail	89
3	4-car Southbound	13:37:03	35' above grade, 60' SW of near rail	92
		13:37:03	12' above grade, 60' SW of near rail	86
		13:37:09	5' above grade, 60' SW of near rail	90
		13:37:08	12' above grade, 60' SW of near rail	89
4	2-car Southbound	14:05:50	35' above grade, 8' SW of near rail	100
		14:05:50	12' above grade, 60' SW of near rail	86
5	2-car Southbound	14:20:22	12' above grade, 60' SW of near rail	86
		14:20:45	5' above grade, 160' SW of near rail	79
		14:20:45	12' above grade, 60' SW of near rail	86
6	2-car Northbound	13:17:32	35' above grade, 77' SW of far rail	77
7	2-car Northbound	13:30:27	35' above grade, 77' SW of far rail	76
8	4-car Northbound	14:02:36	35' above grade, 25' SW of near rail	84

Third-octave band data for a typical train passby at 50 feet (L_{max} of 94 dBA).

Frequency (Hz):	**50**	**63**	**80**	**100**	**125**	**160**	**200**	**250**	**315**	**400**	
L_{max} dB:	70.8	70.7	68.2	64.2	63	64.7	65	64.8	65.6	69.2	
Frequency (Hz):	**500**	**630**	**800**	**1000**	**1250**	**1600**	**2000**	**2500**	**3150**	**4000**	**5000**
L_{max} dB:	70	68.7	75.4	78	90.6	86.2	73.4	73.4	70	68	62.9

Location #3: Sound Transit Link Light Rail, Central Link

Measurements conducted 25 August 2010, using Larson Davis 824 and 831 meters with calibrated microphones.

Passby #	Train	Time	Location	L_{max} (slow)
52nd Avenue South, between Southcenter Boulevard and South 151st Street				
1	4-car Southbound	15:41:30	35' above grade, 50' W of near rail with barrier	71
		15:40:53	5' above grade, 50' W of near rail with barrier	73
		15:40:57	12' above grade, 45'W of near rail with barrier	75
2	4-car Southbound	15:46:23	35' above grade, 50' W of near rail with barrier	73
		15:46:23	5' above grade, 50' W of near rail with barrier	74
		15:46:31	12' above grade, 45'W of near rail with barrier	75
3	4-car Southbound	15:55:57	35' above grade, 50' W of near rail with barrier	70
		15:55:59	5' above grade, 50' W of near rail with barrier	70
		15:55:40	12' above grade, 45'W of near rail with barrier	74
4	4-car Southbound	16:04:36	35' above grade, 50' W of near rail with barrier	71
		16:04:38	5' above grade, 50' W of near rail with barrier	72
		16:04:53	12' above grade, 45'W of near rail with barrier	74
5	4-car Southbound	16:08:08	35' above grade, 50' W of near rail with barrier	72
		16:08:10	5' above grade, 50' W of near rail with barrier	72
		16:08:18	12' above grade, 45'W of near rail with barrier	74
6	4-car Northbound	15:42:7	35' above grade, 50' W of near rail with barrier	73
		15:42:06	12' above grade, 45'W of near rail with barrier	74
7	4-car Northbound	15:55:32	35' above grade, 50' W of near rail with barrier	72
		15:55:33	5' above grade, 50' W of near rail with barrier	71
		15:55:42	12' above grade, 45'W of near rail with barrier	73
8	4-car Northbound	16:02:24	35' above grade, 50' W of near rail with barrier	71
		16:02:24	12' above grade, 45'W of near rail with barrier	73
9	4-car Southbound	16:25:31	35' above grade, 50' W of near rail without barrier	81
		16:25:43	5' above grade, 50' W of near rail without barrier	78
		16:25:43	12' above grade, 45'W of near rail with barrier	73
10	4-car Southbound	16:39:05	35' above grade, 50' W of near rail without barrier	84
		16:39:11	5' above grade, 50' W of near rail without barrier	81
		16:39:18	12' above grade, 45'W of near rail with barrier	74
11	4-car Southbound	16:48:02	35' above grade, 50' W of near rail without barrier	83
		16:48:07	5' above grade, 50' W of near rail without barrier	80
		16:48:16	12' above grade, 45'W of near rail with barrier	73
12	4-car Northbound	16:35:18	35' above grade, 50' W of near rail without barrier	74
		16:35:31	5' above grade, 50' W of near rail without barrier	77
		16:35:35	12' above grade, 45'W of near rail with barrier	75

Passby #	Train	Time	Location	L_{max} (slow)
13	4-car Northbound	16:47:32	35' above grade, 50' W of near rail without barrier	74
		16:47:32	5' above grade, 50' W of near rail without barrier	72
		16:47:39	12' above grade, 45'W of near rail with barrier	74
Macadam Road South and South 128th Street				
1	4-car Southbound	17:37:11	35' above grade, 50' W of near rail	85
		17:37:13	5' above grade, 50' W of near rail	84
2	4-car Southbound	17:43:08	35' above grade, 50' W of near rail	84
		17:43:09	5' above grade, 50' W of near rail	82
3	4-car Northbound	17:42:44	35' above grade, 50' W of near rail	77
		17:42:54	5' above grade, 50' W of near rail	71

Third-octave band data for a typical train passby at 50 feet (L_{max} of 85 dBA).

Frequency (Hz):	**50**	**63**	**80**	**100**	**125**	**160**	**200**	**250**	**315**	**400**	
L_{max} dB:	72.9	67.4	71.1	67.1	64.1	67.8	65.7	66.1	66.0	65.3	
Frequency (Hz):	**500**	**630**	**800**	**1000**	**1250**	**1600**	**2000**	**2500**	**3150**	**4000**	**5000**
L_{max} dB:	68.2	70.1	72.4	72.0	76.1	77.8	73.8	72.9	69.2	62.3	59.1

A P P E N D I X B

Photographs

Location #1: SkyTrain Vancouver, Canada Line

No 3 Road between Capstan Road and Cambie Road

1. Location of 5' and 35' elevated meters, with short parapet barrier shown at track

2. Elevation of track versus meter at 35 feet above grade

Cambie Street just south of Kent Avenue NW

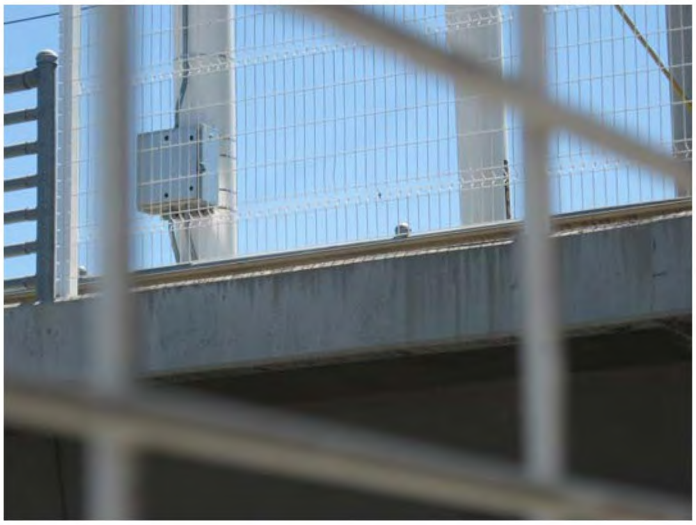
3. Location of 5' and 25' meters above the elevated platform, with short parapet barrier shown at track

4. Sloped track with meter at 25 feet above the elevated platform

Location #2: Santa Clara County VTA Light Rail

Great Mall Parkway between McCandles Drive and Montague Expressway

5. Elevation of track with meter at 35 feet above grade, 8 feet from the near rail



6. Rail visible above the edge of the elevated track platform

7. Train photograph at station; wheels visible from street level

Location #3: ***Sound Transit Link Light Rail, Central Link***

52nd Avenue South, between Southcenter Boulevard and South 151st Street

8. Elevated meter at 35 feet above grade; elevated track with and without barrier

9. Meters at 5 and 12feet above grade; elevated track with and without barrier

Macadam Road South and South 128th Street

9. Meter at 35 feet above grade, with train on far rail of elevated track

10. Sound Transit cars with wheel skirts, while stopped at nearest station